

HISTORICAL BACKGROUND ON THE ORIGIN OF COMPUTER MEDICINE

Martin Lipkin, M.D.

Cornell University Medical College and
Memorial Sloan-Kettering Cancer Center
New York, New York 10021.

ABSTRACT

Major historical contributions to the automation of medical information were made with publication of the Morgagnian Indices of De Sedibus, and with the development of methods using punched cards for storage and sorting of data. In 1952 punched cards were used to automatically correlate data in the differential diagnosis of hematologic diseases, and in 1961 a computer was introduced into medicine for that purpose. The many great advances in the application of computer technology that followed, in so many areas of medical research and practice, have led to revolutionary improvements in bibliographic, laboratory, radiologic and other branches of medicine, and have fulfilled expectations of those active in the field that were only hoped for several decades ago.

During earlier decades of this century, an increasingly large volume of technical information emerged in many scientific fields, leading to the recognition of problems in the efficient classification, correlation and transmission of scientific data. An awareness of this increased during the Second World War, with accelerated activity occurring in many scientific disciplines. An official governmental position developed that methods which had led to the efficient utilization of data in the past were no longer adequate, and should be supplemented by additional techniques. This concern was noted in medical research and practice as well as in other fields. At that time, Dr. Vannevar Bush compared the rapidly growing body of information in science to the Tower of Babel.

Attention to problems of data storage and analysis were not novel in the earlier decades of this century. Over 150 years ago, Dr. Joseph Henry, the first Secretary of the Smithsonian Institution, had stated his belief that available methods of classification and correlation of information were inadequate to handle the bulk of scientific data present at that time. By the third and fourth decades of this century, new methods had been proposed to provide more efficient classification and dissemination of information. They attempted to improve bibliographic data, and suggested storage of information in central locations,

with dissemination by use of abstracts or by selective distribution.

Before and during that period, other techniques also had been developed to provide mechanical assistance in the classification and sorting of technical information. They resulted in the storage of information on cards, with simple sorting of the data carried out using the techniques then available.

In the history of medicine, and in particular in the development of methods of analysis of medical information, a landmark event took place in the 18th Century, when Giovanni Battista Morgagni published the magnificent "De sedibus et causis morborum per anatomen indagatis". These volumes, together with their accompanying Indices, yielded the first successful encyclopedic attempt to accurately correlate pathological and clinical information, in order to assist pathologists and other physicians in the diagnosis of diseases. The publication of De sedibus, was thus an important historical event in which a major concept related to the correlation of medical information was implemented.

By the time the 1930's and 1940's had arrived, with the more rapid accumulation of data that was occurring in medical research, a growing number of investigators began to use punched cards as mechanical aids to classify and correlate data in their respective fields. The punched card methods of data analysis, in turn, were descended from the perforated-card mechanism used in the weaving machine of Morgagni's contemporary, Jacquard. The Jacquard punched-card system represented the culmination of work done by Bouchon (1725), Falcon (1728) and Vaucanson (1745).

According to the medical historian, Jarcho, a line of historical connection can be traced between the Morgagnian correlation exemplified in the indices of De sedibus, and the later development of automated methods of correlation of medical information that arose in the 1950's and 1960's, e.g.,^{8,10}. It appears that a novel extension of the Morgagnian approach to the correlation of medical information had taken place, with the demonstration that information upon which medical diagnosis depended could be automatically correlated using

a computer^{6,8,9,10}. When the original study demonstrating this was first published⁸, a segment of the medical community actively opposed the use of computers in attempting to carry out functions traditionally reserved for other areas of medicine; however, this opposition decreased as further publications demonstrated the broad and effective use of computers in medical research and practice.

In 1952, punched cards were used for the first time for the mechanical correlation of data in the differential diagnosis of hematological diseases^{8,9}, and in 1961 a computer¹⁰ was introduced into medicine for that purpose¹⁰. According to Schmid¹¹, computer medicine began with these events.

Prior to and during that period, Brodman and his co-workers had used a medical history questionnaire to study the efficiency with which that approach might assist medical diagnosis^{12,13}; they later developed further methods of automated data analysis¹⁴. Ledley and Lusted significantly expanded the work of that period, and developed mathematical techniques for medical computing, and for application¹⁵⁻¹⁷ to automated pattern recognition¹⁵⁻¹⁷. Their work provided an important stimulus for the expansion that soon took place in the field of computer medicine.

The first large-scale application of automated techniques to medical practice, was carried out by Collen in his multiphasic screening program¹⁸⁻²⁰. This was broadened by the application of electronic data processing systems to many medical specialties. Computer assisted automation of cardiological diagnosis was carried out^{21,22}, the automation of electrocardiography was accomplished^{23,24}, and the application of computer technology to clinical chemistry laboratories rapidly followed, together with automated pictorial pattern recognition²⁵, microscanning²⁶⁻³¹, and automated differential blood analysis.

The development of techniques of image reconstruction have further led to a revolution in modern medicine. In early work, the assessment of x-ray photographs by automated techniques had been studied^{32,34} by various investigators³²⁻³⁴. Bracewell³⁵ developed procedures in the field of radioastronomy, and later De Rosier and Klug reported on the reconstruction of molecular models³⁶. Techniques of image reconstruction then led to the development of reconstructed tomography³⁷⁻⁴¹, and most recently Hounsfield introduced the X-ray computer-assisted tomography (CAT) scanner^{42,43} which was further extended by Ledley and co-workers⁴⁴.

These advances, which are only briefly mentioned in this article, have summarized major events in the origin and recent history of computer medicine. Of greater importance, is the fact that the magnificent contributions of

computers to all areas of medical research and practice, from the most basic studies to the most important areas of patient care, can now be seen with greater clarity than they were thirty years ago. We cannot yet foresee the full potential of computer medicine, for the most revolutionary of newer concepts and technologies are just beginning to emerge. They are continuing to bring computer medicine into greater symbiosis with medical research and practice, and they are bringing to all of our respective branches of medicine the fulfillment of expectations and achievements that were only hoped for several decades ago.

REFERENCES

- [1] I. Bowman, in "Report to the President on a program for postwar scientific research," Government Printing Office, Washington, D.C. 1945.
- [2] V. Bush, "Science in medicine and related fields," *Med. Ann. Dist. Columbia* 22, 11, 1953.
- [3] J. Henry, "Annual report of Secretary," Smithsonian Institute, Washington, D.C., 1851.
- [4] L.H. Evans, "Bibliography by cooperation," *Bull. M. Library A.* 37: 197-212, 1949.
- [5] J.V. Atanasoff and A.E. Brandt, "Application of punched card equipment to analysis of complex spectra," *J. Opt. Soc. Am.* 26: 83, 1936. L.E. Kuentzel, "New codes for Hollerith type punched cards to sort infrared absorption and chemical structure data," *Anal. Chem.* 23: 10, 1951.
- [6] S. Jarcho, Morgagni and Auenbrugger in the retrospect of two hundred years," *Bull. Hist. of Medicine* 35: 489-496, 1961.
- [7] F. Schreiber and A. Nielsen, "Punch card code for classification of craniocerebral injuries," *J. Michigan M. Soc.* 37: 909-912, 1938. B. Black-Schaffer and P.D. Rosahn, "Studies in syphilis: Methods of analysis of Yale autopsy protocols, including code for punched card study of syphilis," *Yale J. Biol. & Med.* 15: 575-586, 1943. E.P. Allen, "Punch card for neoplastic diseases," *New Zealand M.J.* 12: 121-125 June 1943.
- [8] M. Lipkin and J.D. Hardy, "Differential diagnosis of hematologic diseases aided by mechanical correlation of data," *Science* 125: 551-552, 1957.
- [9] M. Lipkin and J.D. Hardy, U.S. Naval Air Development Center, Report NADC-MA-5505, Johnsville, Pa., 1955. M. Lipkin and J. Hardy, "Medical correlation of data in differential diagnosis of hematological diseases," *JAMA* 166: 113-125, 1958.
- [10] M. Lipkin, R.L. Engle, Jr., B.J. Davis, V.K. Zworykin, R. Ebal, M. Sendrow, C. Berkley, "Digital computer as aid to differential diagnosis," *Archives of Int. Med.* 108: 56-72, 1961.
- [11] J. Schmid, "An historical overview of computer medicine," *Datenjournal* 29: 1-8, 1977; *Health Communications and Informatics* 6: 352-364, 1980.

- [12] K. Brodman, A.J. Erdmann, I. Lorge, and H.G. Wolff, "The Cornell Medical Index: An adjunct to medical interview," JAMA 140: 530-534, 1949.
- [13] K. Brodman, A.J. van Woerkom, A.J. Erdmann, and L. Goldstein, "Interpretation of symptoms with a data-processing machine," Arch. Intern. Med. 103: 776-782, 1959.
- [14] K. Brodman and A.J. van Woerkom, "Computer-aided diagnostic screening for 100 common diseases," JAMA 197: 901-905, 1966.
- [15] R.S. Ledley, Use of computers in biology and medicine, (McGraw-Hill, New York, 1965).
- [16] R.S. Ledley, "High speed automatic analysis of biomedical pictures," Science 146: 216-223, 1964.
- [17] L.B. Lusted, Introduction to medical decision making. (Charles C. Thomas, Springfield, Illinois, 1968).
- [18] M.F. Collen, "Machine diagnosis from a multiphasic screening program," 5th IBM Medical Symposium, Endicott, New York, October 7, 1963.
- [19] M. F. Collen, "Periodic health examinations using an automated multitest laboratory," JAMA 195: 830-833, 1966.
- [20] M.F. Collen, L.S. Davis, and E.E. van Brunt, "The computer medical record in health screening," Methods of Information in Medicine 10: 138-142, 1971.
- [21] C.M. Hyde and R.E. Smith, "Computer applications in cardiology", IBM World Trade Customer Seminar, European Education Centre, Blaricom, The Netherlands, October 6-8, 1965.
- [22] H.R. Warner, A.F. Toronto, and L.G. Veasy, "A mathematical approach to medical diagnosis. Application to congenital heart disease," JAMA 177: 177-183, 1961.
- [23] A.E. Rikli and C.A. Caceres, "Computer techniques for electrocardiography. The use of computers by physicians as a diagnostic aid," Trans. N.Y. Acad. Sci. 23: 237-239, 1961.
- [24] F.W. Stallmann and H.V. Pipberger, Automatic recognition of electrocardiographic waves by digital computer," Circulation Res. 9: 1138-1143, 1961.
- [25] R.A. Kirsch, L. Cahn, L.C. Ray and G.H. Urban, "Experiments in processing pictorial information with a digital computer," Eastern joint computer conference, Washington, D.C. 221-229, 1957.
- [26] R.C. Bostrom and W.G. Holcomb, "A digital screening cytophotometer," IEEE intern. Conv. Record 9: 110-119, 1963.
- [27] M.L. Mendelsohn, W.A. Kolman, B. Perry, and J.M.S. Prewitt, "Morphological analysis of cells and chromosomes by digital computer," Sixth IBM Medical Symposium, 1964.
- [28] L.E. Lipkin, W.C. Watt, and R.A. Kirsch. "The analysis, synthesis and description of biological images," Ann. N.Y. Acad. Sci. 128: 984-1012, 1966.
- [29] R.T. Moore, M.C. Stark and L. Cahn, "Digitizing pictorial information with a precision optical scanner," Joint Annual Meeting of the American Society of Photogrammetry and the American Congress on Surveying and Mapping, 1964.
- [30] D.E. Kuhl and R.Q. Edwards, "Image separation radioisotope scanning," Radiology 80: 653-661, 1963.
- [31] G.L. Wied (ed), Introduction to quantitative cytochemistry. (Academic Press, New York, 1966).
- [32] P.H. Meyers, H.C. Becker, J.W. Sweeney, C.M. Nice, and W.J. Nettleson, "Evaluation of computer-retrieved radiographic image," Radiology 81: 201-206, 1963.
- [33] E.H. Wood, "Data processing in cardiovascular physiology with particular reference to roentgen videodensitometry," Proc. of the Staff Meetings of the Mayo clinic 39: 849-865, 1964.
- [34] G.S. Lodwick, A.H. Turner, L.B. Lusted, and A.W. Templeton, "Computer-aided analysis of radiographic images," J. Chronic Dis. 19: 485-496, 1966.
- [35] R.N. Bracewell, "Strip integration in radio astronomy," Aust. J. Phys. 9: 198-217, 1956.
- [36] D.J. DeRosier and A. Klug, "Reconstruction of three dimensional structures from electron micrographs," Nature (London) 217: 130-134, 1968.
- [37] M.V. Berry and D.F. Gibbs, "The interpretation of optical projections," Proc. R. Soc. A. 314: 143-152, 1969.
- [38] P.D. Rawley, "Quantitative interpretation of three-dimensional weakly refractive objects using holographic interferometry," J. Opt. Soc. Am. 59: 1496-1498, 1969.
- [39] A.M. Cormack, "Representation of a function by its line integrals with some radiological applications," J. Appl. Phys. 34: 2722, 1963.
- [40] A.M. Cormack "Representation of a function by its line integrals with some radiological applications," II. J. Appl. Phys. 35: 2908-2913, 1964.
- [41] C.J. Treliak, M. Eden, and W. Simon, Proc. 8th Int. Conf. on Med. Biol. Eng., Session 12-1, Chicago, 1969.
- [42] G.N. Hounsfield, British Patent No. 1283915, 1972.
- [43] G.N. Hounsfield, "Computerized transverse axial scanning (tomography). Part 1. Description of system," Br. J. Radiol. 46: 1016-1022, 1973.
- [44] R.S. Ledley, G. Di Chiro, A.J. Luessenhop and H.L. Twigg, "Computerized x-ray tomography of the human body," Science 186: 207-212, 1974.

INDEX the SECOND,

REFERRING TO

Diseases and their Symptoms, to their External Causes, to the different Stages of Life, to the various Employments of Life, and other Things of a similar Nature.

The Roman or Capital Figures refer to the Letters; the Common or Small Figures to the Articles.

A

ABDOMEN, blackish, XLI. 10.
Beaten with a stick, XLIX. 6.
Kick'd by a horse, LIV. 14-41.
Bruis'd in the right epicolic region, LIV. 29.
Pain of, XLIX. 6.
Gangrene of. See Gangrene.
Wound of in the epigastrium, LIV. 8. 10.
In the left hypochondrium, LIV. 35.
At the margin of the right os ilium, LIV. 4.
In the left epicolic region, LIV. 37.
At the bottom of the right epicolic region, LIV. 33.
Below the navel, LIV. 6. 20.
In the hypogastrium, LIV. 31.
About the groin, LIV. 2.
Abortion, XXI. 24. XXXIX. 12. Vid. Fetus.
Achores, X. 9.
Air, effects of going from thin into foul, XLIX. 14. Vid. Cold.
Amaurosis, IX. 20. Vid. Eye.
Anafarca, XVI. 4. XXII. 10. XXXVIII. 6. 26.
Aneurism. Vid. Arms, Groin, Ham.
Anger, XXXV. 16.
Angry-man, XXXV. 2.
Anus, excrescences about the, XLVII. 28.
Condylomata of the, XLII. 2.

Anus, constant bleeding of the, XLII. 2.
Anxiety, XXX. 4. XXXIV. 9. XXXVI. 17. LV. 2.
Aphonia. Vid. Speech, loss of.
Apoplexy, I. 4. II. 9. 11. 13. 15. 16. 17. 19. 20. 22. III. 2. 4. 6. 11. 14. 16. 17. 20. 24. 26. IV. 4. 9. 11. 13. 16. 20. 21. 24. 26. 28. 30. V. 2. 15. 17. 19. VI. 6. XI. 6. 13. 15. 22. XIV. 27. XXXV. 6. XLVII. 24. LI. 30. 37. 59. LII. 38. LVI. 12. LVII. 2. 14. LX. 2. 4. 6. 8. 10. LXII. 7. 9. 11.
three attacks of, LX. 4. 6. LXII. 11.
Coming-on on change of posture whilst lying down, LI. 30.
Imperfect. IV. 2. 6. 7. 8. 19. V. 6. 11. XLIV. 21. Vid. also Hemiplexy.
Appetite, loss, XII. 16. XX. 15. 28. XXIII. 4. XXVI. 13. XXIX. 10. 12. XXX. 7. XLII. 13. XLIX. 2. L. 48. LXV. 13.
Arm, aneurism of the from bleeding, L. 7.
Pain of the, XVI. 36. XXIV. 34. XXVII. 8.
Numbness of the, XXVI. 31.
Trembling of the, XXX. 4.
Aphuxy. Vid. Pulse, defect of.
Asthma, XV. 13. XVIII. 34. XLVI. 17. LII. 8. LXVII. 9. Vid. Respiration, difficulty of.

Figure 1.

A page from Morgagni's Second Index of Desidibus, enumerating symptoms derived from diseases, and the corresponding text locations where correlations can be made with other findings

Figure 2.

Marginal punched card used in the study of reference^{8,9} for the storage and automatic correlation of data in the differential diagnosis of hematologic diseases

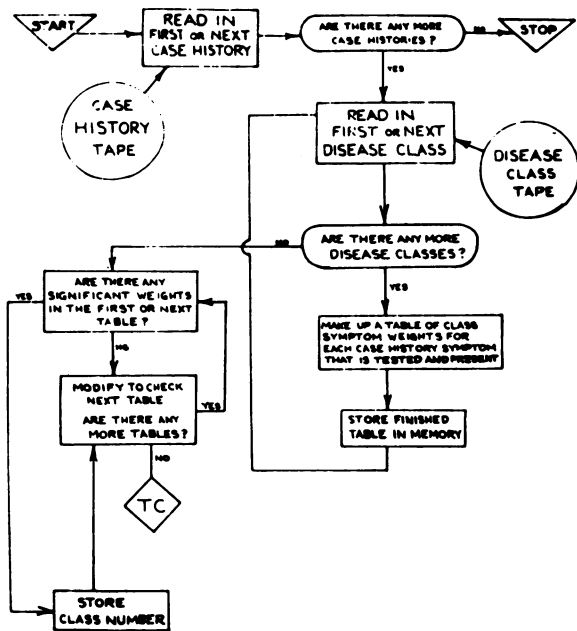
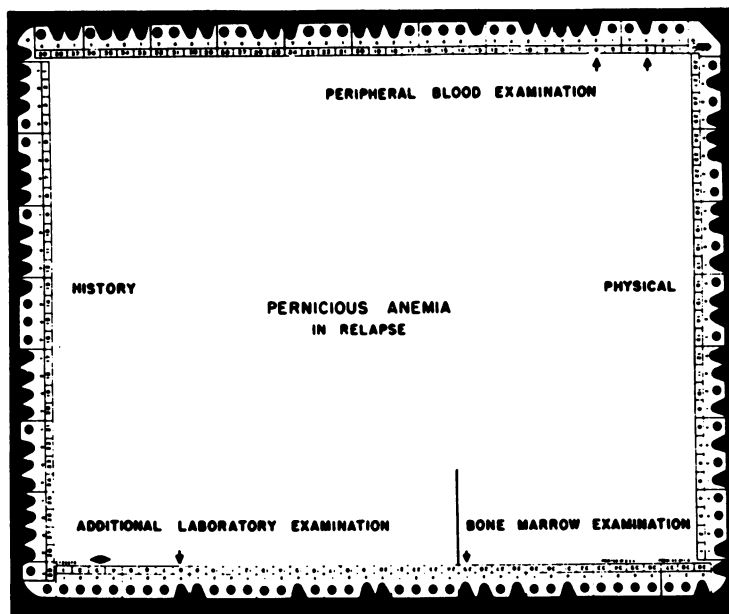


Figure 3.

Flow diagram used in the study of reference¹⁰, where the differential diagnosis of hematologic diseases was carried out with a digital computer.